FIRE DOOR

Field of the Invention

The present invention relates to fire door assemblies comprising a door frame and an associated fire door. In particular, the invention relates to a fire door having a support structure connected to a layer of insulating material which reduces the transfer of heat between the frame and the support structure.

Background of the Invention

Numerous building codes have been enacted by federal, state and local governments to promote public safety. In particular, some of these regulations require fire resistant structures and materials such as, for example, panels, insulation and the like to be installed in the buildings to reduce the spread of heat and fire. Generally, multi-story buildings have openings between floors to provide access and/or ventilation between floors. These openings can be used to access crawl spaces, transport equipment between floors and the like. However, such openings can pose a safety hazard in the event of a fire, since these openings provide a pathway for fire to spread to adjacent floors. Consequently, building regulations typically require these openings to be occluded with fire resistant materials.

One way of occluding the openings between floors in multi-story buildings is to install fire doors that are designed to prevent the spread of heat and fire between adjacent floors. The door can be opened to provide access between floors through the opening and closed to block the opening, for example, to resist the spread of fire. In some embodiments, the fire doors

have structure which holds the door in an open position, and can further comprise a heat sensitive closing mechanism which automatically closes the door in the event of a fire.

NFPA 288 provides an industry standard for obtaining a temperature rating on a fire door based on a maximum desired temperature on an unexposed surface away from direct exposure to the fire to prevent the effect of a fire from the floor below from causing damage to the floor above. The NFPA 288 procedure is incorporated herein by reference. Generally, some form of insulation is required to achieve a satisfactory rating under the NFPA 288 procedure. However, fire doors are generally composed of metal, and therefore can contain metal to metal contacts that provide heat transfer pathways between, for example, the bottom surface of the door and the top surface of the door. These heat transfer pathways can increase the temperature on the top surface of the door, which can lower the fire rating of the door and/or increase the amount of insulation required to achieve a particular fire rating.

Summary of the Invention

In a first aspect, the invention pertains to a fire resistant door comprising a door frame having structural elements defining an opening and a door sized to fit into the frame and occlude the opening. In these embodiments, the door can comprise a top member configured to have a selected orientation in a closed configuration with the door engaging the frame and a first layer of insulation material positioned along the bottom surface of the door. Additionally, the door can further comprise a support structure connected to the first layer of insulation material to hold the first layer of insulation in a fixed position that is spaced apart relative to the top

member, wherein the first layer of insulation material engages the frame in the closed configuration without any contact between the support structure and the frame.

In another aspect, the invention pertains to a fire resistant door comprising a door frame having structural elements defining an opening and a door sized to fit into the frame and occlude the opening, the door having a top surface and a bottom surface. In these embodiments, the door can comprise a first layer of insulation material oriented towards the bottom surface of the door and a second layer of insulation material oriented towards the top surface of the door. Additionally, the door can further comprise a support structure connected to the first layer of insulation material to hold the first layer of insulation material in a fixed position relative to the second layer of insulation material such that a gap exists between the first layer of insulation material and the second layer of insulation material.

In a further aspect, the invention pertains to a method of preventing the spread of fire through an opening. In these embodiments, the method comprises providing a fire door assembly sized to occlude the opening, wherein the fire door assembly comprises a door frame and a door, and wherein the door comprises a first layer of insulation material connected to a support structure such that the no contact exists between the support structure and the frame when the door is in a closed configuration. In some embodiments, the method can further comprise moving the door from an open configuration to a closed configuration in response to a fire.

Brief Description of the Figures

Fig. 1 is a perspective view of a fire door assembly comprising a frame and a door, wherein the door is in an open configuration relative to the frame with structure being displayed as transparent to show hidden structure;

Fig. 2 is a side view of the fire door assembly of Fig. 1, wherein the door is in an open configuration relative to the frame with structure being displayed as transparent to show hidden structure;

Fig. 3 is a cross-sectional view of the fire door assembly of Fig. 1, wherein the door is in a closed configuration relative to the frame, with the cross section taken through a plane generally along the extent of the door and frame;

Fig. 4 is a perspective view of a fire door showing an angle structure connected to a support member; and

Fig. 5 is a perspective view of the fire door of Fig. 4 having circles indicating the points of contact between the angle structure and the support member.

Detailed Description of the Invention

Improved fire door assemblies comprise a door frame having structural elements defining an opening, and a door sized to fit into the frame and occlude the opening. Generally, the door can further comprise a top member, a first layer of insulation material positioned along a bottom surface of the door and a support structure connected to the first layer of insulation material. Due to the design of the support structure and the first insulation layer, direct contact between the support structure and the door frame is reduced or eliminated, which can reduce heat

transfer pathways between the door frame and the door. In one embodiment, the support structure can comprise a support member connected to angle structure, wherein the first layer of insulating material is connected to the angle structure. The angle structure can provide a surface for connecting the first layer of insulating material to the support structure. In some embodiments, a second insulation layer can be oriented towards the top surface of the door. In these embodiments, the support structure can hold the first insulation layer in a fixed position relative to the second layer of insulation material such that a gap is located between the first layer of insulation material and the second layer of insulation material. The first and second layers of insulation material, along with the gap between the two layers, can reduce the heat transfer between the bottom surface of the door and the top surface of the door. Generally, the door and the door frame can comprise metal such as, for example, aluminum.

As described above, fire doors can be used to occlude openings between floors of, for example, multi-story buildings. To achieve a satisfactory NFPA 288 and/or ASTM-E119 rating, fire doors have employed a layer of insulation such as, for example, mineral wool or fiber board, and/or have coated the door with a layer of intumescent material. Generally, intumescent material swells or puffs up to a relatively thick cellular foam char in response to heat. However, both the door and the door frame of known fire door assemblies are composed of metal, which can create metal to metal contacts between the frame and the door. These metal to metal contacts can create a heat flow paths between the frame and the door, which facilitates the transfer of heat from the bottom surface of the door to the top surface of the door. Since the fire doors are designed to prevent the spread of heat and fire between, for example, adjacent floors of a building, it is undesirable to have heat flow pathways between the bottom surface of the door

and the top surface of the door. As described herein, one way of reducing the heat flow pathways between the bottom surface of the door and the top surface is to employ a door comprising a support structure connected to a first layer of insulation material such that direct contact between the support structure and the frame is eliminated. This contact is replaced with contact between an insulating member integrated into the door and the door frame. Additionally, heat flow from the bottom surface to the top surface can be reduced by employing a first layer of insulation material and a second layer of insulation material, wherein a gap is provided between the first layer of insulation material and the second layer of insulation material.

In some embodiment, the fire door generally comprises a top surface, a first layer of insulation oriented towards the bottom surface of the door and a support structure connected to the first layer of insulation material. Generally, the support structure holds the first layer of insulation in a fixed position relative to the top member. In some embodiments, the support structure can hold the first layer of insulation material such that the first layer of insulation material engages the door frame in the closed configuration without any contact between the support structure and the frame with the first layer of insulation forming the exposed bottom surface of the door. Thus, since the support structure does not directly contact the door frame, heat transfer from the frame through the support structure to the top surface of the door can be reduced. In some embodiments, the support structure can comprise a support member connected to the top member of the door and an angle structure connected to the support member. In one embodiment, only six points of contact exist between the angle structure and the support member, which reduces heat transfer through the support structure to the top surface of the door.

As described above, in some embodiments the fire door can further comprise a second layer of insulation material oriented towards a top surface of the door. In these embodiments, a support structure can hold and position the first layer of insulation material in a fixed position relative to the second layer of insulation material such that a gap exists between the first layer of insulation material and the second layer of insulation material. The first and second layer of insulation, along with the gap between the two layers, can reduce the heat transfer from the bottom surface of the door to the top surface of the door. In some embodiments, the first layer of insulating material can comprise a plurality of layers of an endothermic blanket material coupled together to form a composite structure, while the second layer of insulating material can comprise, for example, a non-woven mineral fiber material. In other embodiments, the first layer of insulation material and the second layer of insulation material can comprise the same type of insulation.

A fire door assembly incorporating desired features of the improved door and frame is depicted in Figs. 1-3. Referring to Figs. 1-3, a fire door assembly 100 is shown comprising door frame 102 and door 104. In some embodiments, door 104 can be pivotally coupled to frame 102 by one or more hinges 105 such that door 104 can be moved from an open position to a closed position through rotation of the hinges. However, other embodiments exist where door 104 is not pivotally coupled to frame 102. In these embodiments, door 104 can be provided with a plurality of handles, which facilitates manually inserting and removing door 104 from frame 102. As shown in Fig. 1, frame 102 can comprise a plurality of structural elements 106 which define an opening 108. Frame 102 can be provided with an external flange 107, which facilitates engagement of door frame 102 with a surface such as, for example, a floor.

Generally, door 104 can comprise top member 110, support structure 112 and first insulation layer 114. In some embodiments, top member 110 defines a top surface 111 of door 104. As discussed below, support structure 112 can be connected to first insulation layer 114 such that the first insulation layer 114 can be held in a fixed position relative to top member 110. Additionally, as shown in Fig. 3, door 104 can comprise a second layer of insulation material 122 oriented towards top member 110. In some embodiments, support structure 112 can hold first layer of insulation material 114 in a fixed position relative to second layer of insulation material 122 such that a gap 124 exists between the first layer of insulation material 114 and the second layer of insulation material 122.

Door 104 can further comprise a heat activated self-closing mechanism 118 which functions to move door 104 from an open configuration (shown in Fig. 1) into a closed configuration (shown in Fig. 3) in the event of a fire. In some embodiments, heat activated self-closing mechanism 118 can comprise collapsible supporting member 120 and a trigger mechanism. Generally, collapsible supporting member 120 holds the door in the open configuration. In the event of a fire, the trigger mechanism can interact with the collapsible supporting member 120 to move door 104 into the closed configuration. Additional description of self closing mechanisms suitable for use in fire door assemblies can be found in U.S. Patent No. 6,615,544 to Tlemcani et al., entitled "Fire-Resistant Door," which is hereby incorporated by reference herein.

As described above, frame 102 can comprises a plurality of structural elements 106 which define opening 108. In some embodiments, frame 102 can have a rectangular cross-section, however, one of ordinary skill in the art will recognize that no particular cross-sectional

shape of frame 102 is required by the present disclosure. Additionally, the size of frame 102, and of opening 108, can be guided by the intended application of a particular fire door assembly. Referring to Fig. 1, frame 102 can comprise external flange 107 which can facilitate sealing fire door assembly 100 to a floor or other surface. As shown in Fig. 3, frame 104 can further comprise an internal flange 124, which functions as a stop for door 104 when door 104 is in the closed configuration. Frame 102 can be composed of any material suitable for use in fire door application including, for example, metals, metal alloys and combinations thereof, to provide desired levels of mechanical strength. In one embodiment, frame 102 can comprise aluminum, however, one of ordinary skill in the art will recognize that any metal suitable for use in fire door applications may be used to form frame 102.

Generally, door 104 is sized to fit into frame 102 and occlude opening 108. Thus, the size and cross-sectional shape of door 104 can be guided by the corresponding size and cross-sectional shape of frame 102. As shown in Fig. 3, a gasket 126 can be connected to top member 110 to seal door 104 to internal flange 124 when door 104 is in the closed configuration. Gasket 126 can be composed of any material such as, for example, fiberglass or the like, suitable for use in fire door applications. Door 104 can further comprise a latch system which functions to secure door 104 to frame 102 when door 104 is in the closed configuration. In one embodiment, latch system can comprise latches 127 connected to a central member 129 by cables (not shown). Latches 127 generally comprise retractable protrusions which engage frame 102 in the closed configuration. In some embodiments, to release latches 127, central member 129 can be rotated, which actuates the cables attached to the latches 127 such that the protrusions can be retracted and door 104 can be moved into the open configuration. Generally, central member 129 is

connected to a release handle located on top surface 111 of door 104 such that the rotation of central member 129 can be accomplished by actuating the release handle. Additionally, top member 110 can comprise one or more handles which facilitate manually moving door 104 into the open or closed configuration. Top member 110 can be composed of any material suitable for use in fire door application including, for example, metals, metal alloys and combinations thereof, to provide desired levels of mechanical strength. In one embodiment, top member 110 can comprise aluminum.

As described above, first layer of insulation material 114 can be held in a fixed position relative to top member 110 by support structure 112. As described below, the support structure is generally designed such that the support structure does not directly contact door frame 102 when door 104 is in the closed configuration. By eliminating contact between door frame 102 and support structure 112, heat transfer from door frame 102 to support structure 112, and ultimately to top member 110, can be reduced. Referring to Figs. 3-4, support structure 112 can comprise support member 130, which is attached to and extends away from top member 110 to provide structural support and rigidity to top member 110. Generally, support member 130 can comprise a plurality of structural elements that are connected such that an internal door area 140 is defined by support member 130. As shown in Fig. 4, support structure can also comprise one or more cross bars 132 which can be connected to support member 130 and provide additional support and rigidity for top member 110. In embodiments comprising a second layer of insulation material, the second layer of insulation can be positioned in the internal door area 140 between cross bars 132.

In some embodiments, support structure can further comprise an angle structure or bracket 134 connected to support member 130. Generally, the angle structure provides as surface for mounting or connecting the first layer of insulation material 114 to the support structure that reduces the contact points between the various components of the support structure. In one embodiment, angle structure 134 can comprise a vertical component 136 and a horizontal component 138. In some embodiments, angle structure 134 can be formed by multiple elements that are connected together, while in other embodiments angle structure 134 can be formed by a unitary element that is formed into the desired shape during processing of the element. Vertical component 136 can be connected to support member 130, while horizontal component 138 can provide a surface for mounting the first layer of insulating material 114 to door 104. As shown in Fig. 5, angle structure 134 can be connected to support member 130 such that only six points of contact 142 are established between angle structure 134 and support member 130. In further embodiments where the central angle bracket, shown exploded from door 104 in Fig. 5, is not employed, only 4 points of contact exist between angle bracket 134 and support member 130. Reducing the contact between angle structure 134 and support member 130 reduces the heat transfer pathways from angle structure 134 to support member 130, which can reduce heat transfer to top member 110.

As described above, door 104 can comprise first layer of insulation material 114, which functions to reduced heat transfer from the bottom surface 116 of door 104 to the top surface 111. In some embodiments, bottom surface 116 of door 104 can be formed by the first layer of insulation material 114, while in other embodiments bottom surface 116 can be formed by, for example, a metal sheet or the like attached to first layer of insulation material 114. As

shown in Figs. 2 and 3, first layer of insulation material 114 can be formed by coupling a plurality of insulation layers 128 together to form a composite insulation structure. Generally, adding additional layers of insulation reduces the heat flow from bottom surface 116 to top surface 111 during a fire. In one embodiment, insulation layers 128 can be coupled together by, for example, a plurality of mechanical fasteners 131. Mechanical fasteners 131 can be any fasteners suitable for use in fire door applications such as, for example, metal screws, metal pins, and the like. In some embodiments, mechanical fasteners 131 can be aligned such that no contact exists between fasteners 131 and support member 130, which reduces potential heat transfer pathways through first layer of insulation material 114.

As shown in Fig. 3, in embodiments where the first layer of insulation material 114 is composed of a plurality of layers 128 of insulation, the layer of insulation closest to top member 110 can be directly connected to horizontal component 138 of angle structure 134 by fasteners 142. Additionally, fasteners 142 can be covered by additional layers 128 of insulation material, which can insulate fasteners 142 and reduce heat flow to angle structure 134. Reducing the heat flow through fasteners 142 to angle structure 134 can reduce the overall heat transfer to top surface 111 of door 104. Furthermore, as shown in Fig. 3, fastener 142 can also be insulated from heat by a layer of cement 144, or other floor materials, which can surround frame 102 and extend under frame 102. By extending cement layer 144 under fastener 142, and angle structure 134, cement layer 144 can provide additional insulation for angle structure 134, which can reduce heat transfer to top member 110. In embodiments where first insulation layer 114 comprises a plurality of layers 128, the portion of cement layer 144 that extends under fastener 142 can contact first insulation layer 114 and provide support to reduce the formation of gaps

and/or seams between layers 128 during fire conditions. Extending cement layer 144 under fire door assembly 100 can also provide a barrier between frame 102 and potential heat and fire, which can insulate frame 102 and reduces heat transfer to frame 102 and door 104. As shown in Fig. 3, when door 102 is in the closed configuration, first layer of insulation material 114 can contact frame 102. Thus, the design of support structure 112 prevents direct contact between door frame 102 and support structure 112, which can reduce heat transfer from frame 102 to door 104.

First layer of insulation material 114 can be composed of any material suitable for use in fire door applications. Suitable materials include, for example, endothermic blanket materials composed of ceramic fibers having bound water molecules located within the ceramic fibers, non-woven mineral fibers, non-woven mineral fibers impregnated with fiberglass, fiber board and combinations thereof. Preferred endothermic blanket materials are sold by 3M under the trademark Interam™. In one embodiment, first layer of insulation material 114 can comprise Interam™ E-5A material. In some embodiments, first layer of insulation material 114 can be a composite structure comprising 1-6 layers of insulation material, while in other embodiments first layer of insulation material 114 can comprise 2-4 layers of insulation. One of ordinary skill in the art will recognize that additional layers of insulation material are contemplated and are within the scope of the present disclosure. In some embodiments, all of the layers 128 of insulation material coupled to form first layer of insulation 114 can be the same type of insulation material, while in other embodiments the layers 128 of insulation can be different types of insulation. One of ordinary skill in the art will recognize that the number and type of

insulation coupled to form first insulation layer 114 can be guided by the intended application and desired fire rating of a particular fire door assembly.

In some embodiments, door 104 can further comprise second layer of insulation material 122 oriented towards the top surface 111 of door 104. Second layer of insulation material 122 provides additional insulation for top member 110 and reduces heat transfer to top surface 111 of door 104. In some embodiments, second layer of insulation material can be connected to top member 110 by, for example, mechanical fasteners, adhesives or combinations thereof. Second layer of insulation material 122 can be any material suitable for use in fire door applications including, for example, intumescent materials, endothermic blanket materials, non-woven mineral fibers impregnated with fiberglass, fiber board, mineral wool or combinations thereof. In one embodiment, second layer of insulation material can be composed of a 3M® duct wrap material comprising non-woven mineral fibers impregnated with fiberglass. As shown in Fig. 3, support structure 112, which can comprise support member 130 and angle structure 134, can hold first layer of insulation material 114 in a fixed position relative to second layer of insulation material 122 such that a gap 124 exists between first layer of insulation material 114 and second layer of insulation material 122. Gap 124 can reduce heat transfer to top member 110 since the air, or other gasses, located in gap 124 can absorb heat.

As described above, multi-story buildings such as, for example, hotels, office towers, apartment buildings and the like are subject to specific fire related building codes and regulations. As a result, the floors, doors, ceilings and other structures must generally pass specific fire ratings. Additionally, openings are generally present in multi-story buildings to provide access and/or ventilation between floors. These openings can allow a fire to spread

between adjacent floors, and therefore building codes and regulations generally require these openings to be occluded with fire rated materials. The fire door assemblies described above can be used to occlude such openings between floors in hotels, office towers and the like. The fire door assemblies of the present disclosure comprise structure to reduce heat transfer between the frame and the door, which can reduce potential heat transfer between adjacent floors in a multi-story building. Furthermore, the combination of two layers of insulation material, along with a gap between the two layers, also can reduce heat flow between adjacent floors of a building.

The embodiments above are intended to be illustrative and not limiting. Additional embodiments are within the claims. Although the present invention has been described with reference to particular embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.